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INVENTION: ELECTROSTATIC COATING GUN

Hon. Commissioner of Patents and Trademarks,
Washington, D.C. 20231

SIR:

CERTIFIED TRANSLATION

I, Masato TANINAKA, am a translator of the Japanese language into the English language and I hereby certify that the attached comprises an accurate translation into English of Japanese Patent Application No. 2003-87882, filed March 27, 2003.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

March 20, 2008 Masato Taninaka

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[Title of the Invention] ELECTROSTATIC COATING SPRAY GUN

[Number of Claims] 7

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[Name of Document] SPECIFICATION

[Title of the Invention] ELECTROSTATIC COATING SPRAY GUN

[Claims]

[Claim 1] An electrostatic coating spray gun for electrifying a coating material atomized with compressed air and coating the same onto a substance to be coated, characterized by:

a pin electrode protruding forward from a coating material delivery port located at a central part of an air cap attached to a distal end of a barrel serving as a body of the electrostatic coating spray gun;

square sections which are formed at radially upper and lower positions of the air cap with the pin electrode being interposed therebetween so as to protrude forward from the coating material delivery port;

insulatively shielded electrodes enclosed in the respective square sections with a surface thereof being covered with an electrical insulating material, and in that

the pin electrode is grounded and a DC high voltage is applied between the pin electrode and the insulatively shielded electrodes.

[Claim 2] The electrostatic coating spray gun according to claim 1, further characterized by square sections which are formed at radially right and left positions of the air cap with the pin electrode being interposed therebetween so as to protrude forward from the coating material delivery port, and insulatively shielded electrodes enclosed in the respective

square sections with a surface thereof being covered with an electrical insulating material, and in that a DC high voltage is applied between the pin electrode and the insulatively shielded electrodes.

[Claim 3] The electrostatic coating spray gun according to claim 1, characterized in that instead of the square sections and the insulatively shielded electrodes, a ring-shaped portion projecting forward from the coating material delivery port is formed at the surrounding of the air cap so that the ring-shaped portion surrounds the pin electrode, a ring-shaped insulatively shielded electrode whose surface is covered up with an electrically insulating material is accommodated in the interior of the ring-shaped portion, and high dc voltage is applied between the grounding and the ring-shaped insulatively shielded electrode.

[Claim 4] The electrostatic coating spray gun according to any one of claims 1 to 3, characterized in that the pin electrode is eliminated, instead thereof, a portion that forms the coating material delivery port is composed of a conductive material, and high dc voltage is applied between the grounding and the insulatively shielded electrode.

[Claim 5] The electrostatic coating spray gun according to any one of claims 1 to 3, characterized in that the pin electrode is eliminated, a paint having conductivity is used as the coating material, and high dc voltage is applied between the

grounding and the insulatively shielded electrode.

[Claim 6] The electrostatic coating spray gun according to any one of claims 1 to 5, characterized in that part or all of the electrical insulation material covering the surface of the insulatively shielded electrode is eliminated.

[Claim 7] The electrostatic coating spray gun according to any one of claims 1 to 6, characterized in that a shaping air spout port is provided at the outside portion of the outer cylinder of the air cap in the vicinity of the tip end of the barrel being the main body of the electrostatic coating spray gun, and compressed air is spouted forward along the outer cylinder surface of the air cap from the corresponding shaping air spout port.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an electrostatic coating spray gun, in particular, to a spray gun suitable for electrostatic coating, using an aqueous coating material or a metallic coating material whose electric resistance is relatively low.

[0002]

[Prior Art]

Generally, in coating materials used for electrostatic coating of vehicle bodies, etc., there is a solvent-based coating

material (oil-based coating material) whose electric resistance is relatively high, an aqueous coating material (water-based coating material) whose electric resistance is relatively low, and a metallic coating material in which metallic powder is dispersed in the above coating materials. Of these, where carrying out electrostatic coating using an aqueous coating material or a metallic coating material whose electric resistance is relatively low, a current is caused to flow to the ground via a coating material feeding channel and a coating material tank if high voltage is applied directly to a charge electrode of an electrostatic coating spray gun which is brought into contact with the coating material. Therefore, no electric discharge is brought about between the charge electrode and a substance to be coated, wherein atomized coating material particles cannot be electrified.

[0003]

As a prior art to solve the problem, for example, there is a method for electrically insulating a coating material tank from the ground. According to the method, high voltage can be applied between a charge electrode of an electrostatic coating spray gun and a substance to be coated, wherein coating material particles can be electrified. However, it is necessary that painting or coating work is interrupted when supplementing a coating material since high voltage is applied to the coating material tank, or a special coating material supplementing apparatus (for example, refer to Patent Document 1) is required, which supplies a coating material in a state where electric insulation from the coating material tank is maintained. Therefore, it is

inconvenient.

[0004]

As another solving means, there is a system called an "external electrode system" in which one or a plurality of external electrodes is (are) disposed at an outward position in the diametrical direction from an electrostatic coating spray gun, and high voltage is applied thereto. In this system, there is a system (for example, refer to Patent Document 2) in which a rotary atomizer head is used to atomize a coating material in an electrostatic coating spray gun, and an air spray system (for example, Patent Document 3) in which compressed air is used. In both systems, since there is no case where an external electrode for applying high voltage is brought into contact with a coating material whose electric resistance is low, it is possible to electrify coating material particles with the coating material tank grounded. Accordingly, no special apparatus is required to supply a coating material into a coating material tank, wherein continuous coating is enabled. However, since, in the case of the external electrode system, the external electrode is attached outside an electrostatic coating spray gun, the electrostatic coating spray gun is made large-sized, and this is dangerous because the electrode to which high voltage is applied is provided outside the main body. In addition, there is another problem in that atomized coating material particles are adhered to the vicinity of the external electrode or the surrounding of the electrostatic coating spray gun due to an electrostatic force.

[0005]

[Patent Document 1]

Japanese Published Unexamined Patent Application No. 2002-143730

[0006]

[Patent Document 2]

Japanese Published Unexamined Patent Application No. H06-134353

[0007]

[Patent Document 3]

Japanese Published Unexamined Patent Application No. H09-136047

[0008]

[Problem to be Overcome by the Invention]

The invention was developed based from such backgrounds. It is therefore an object of the invention to provide an air spray type electrostatic coating spray gun that can be used for electrostatic coating using an aqueous coating material and metallic coating material whose electric resistance is relatively low, is able to carry out coating with its coating material tank grounded, and has a compact structure in which no electrode is provided outside the main body.

[0009]

[Means for Overcoming the Problem]

To achieve the object of the invention, the invention of claim 1 is an electrostatic coating spray gun for electrifying a coating material atomized with compressed air and coating the same onto a substance to be coated, characterized by a pin electrode protruding forward from a coating material delivery

port located at a central part of an air cap attached to a distal end of a barrel serving as a body of the electrostatic coating spray gun, square sections which are formed at radially upper and lower positions of the air cap with the pin electrode being interposed therebetween so as to protrude forward from the coating material delivery port, insulatively shielded electrodes enclosed in the respective square sections with a surface thereof being covered with an electrical insulating material, and in that the pin electrode is grounded and a DC high voltage is applied between the pin electrode and the insulatively shielded electrodes.

[0010]

According to the above-described structure, since the surface of the electrode to which high dc voltage is applied is covered up with an electrically insulating material, no current is allowed to flow between the insulatively shielded electrodes and the pin electrode. Therefore, high voltage can be applied in a state where the interval between the insulatively shielded electrodes and the pin electrode is made comparatively narrow, wherein an intensive electric field can be generated in the vicinity of the pin electrode, in particular, in the vicinity of the tip end thereof, coating material particles atomized by atomization air can be electrified with the inverse polarity of the polarity of the insulatively shielded electrodes. The electrified coating material particles are conveyed in close proximity to a substance to be coated by means of pattern air, and can be coated onto the substance to be coated, by means of an electrostatic force. With such an action, according to the

electrostatic coating spray gun, it is possible to carry out electrostatic coating of not only a solvent-based coating material but also an aqueous coating material and metallic coating material whose electric resistance is relatively low. In addition, since such an external electrode as in the prior art is not required, the spray gun can be formed compact.

[0011]

The insulatively shielded electrode in the invention includes an electrode having a surface coated with an electrical insulating material, an electrode having a surface oxidized into an insulating film, and an electrode including a bare electrode housed in a space surrounded by an electrical insulating material.

[0012]

Furthermore, the claim recites square sections which are formed at radially upper and lower positions of the air cap with the pin electrode being interposed therebetween so as to protrude forward from the coating material delivery port and insulatively shielded electrodes enclosed in the respective square sections with a surface thereof being covered with an electrical insulating material. The recitation includes the construction that a ring-shaped portion projecting forward from the coating material delivery port is formed at the surrounding of the air cap so that the ring-shaped portion surrounds the pin electrode, a ring-shaped insulatively shielded electrode whose surface is covered up with an electrically insulating material is accommodated in the interior of the ring-shaped portion.

[0013]

Furthermore, the grounding of the pin electrode includes grounding with a conductive paint used as an electrical path other than the grounding by the use of wiring cable.

[0014]

The invention of claim 2 is the electrostatic coating spray gun according to claim 1 which is further characterized by square sections which are formed at radially right and left positions of the air cap with the pin electrode being interposed therebetween so as to protrude forward from the coating material delivery port, and insulatively shielded electrodes enclosed in the respective square sections with a surface thereof being covered with an electrical insulating material, and in that a DC high voltage is applied between the pin electrode and the insulatively shielded electrodes.

[0015]

According to the construction, the electric field intensity near the pin electrode, particularly the distal end thereof, is increased such that an ionization area formed about the pin electrode can be spread and atomized coating material particles can effectively be electrified.

[0016]

Furthermore, the invention of claim 3 is the electrostatic coating spray gun according to claim 1 which is characterized in that instead of the square sections and the insulatively shielded electrodes, a ring-shaped portion projecting forward from the coating material delivery port is formed at the surrounding of the air cap so that the ring-shaped portion surrounds the pin electrode, a ring-shaped insulatively shielded

electrode whose surface is covered up with an electrically insulating material is accommodated in the interior of the ring-shaped portion, and high dc voltage is applied between the grounding and the ring-shaped insulatively shielded electrode.

[0017]

According to the construction, the electric field intensity near the pin electrode, particularly the distal end thereof, is increased such that an ionization area formed about the pin electrode can be spread and atomized coating material particles can effectively be electrified, as in the invention of claim 2.

[0018]

Furthermore, the invention of claim 4 is the electrostatic coating spray gun according to any one of claims 1 to 3 which is characterized in that the pin electrode is eliminated, instead thereof, a portion that forms the coating material delivery port is composed of a conductive material, and high dc voltage is applied between the grounding and the insulatively shielded electrode.

[0019]

According to the construction, the same effect can be achieved as by the invention of claim 1 although the intensity and rate at which the atomized coating material particles can effectively be electrified are slightly reduced.

[0020]

Furthermore, the invention of claim 5 is the electrostatic coating spray gun according to any one of claims 1 to 3 which is characterized in that the pin electrode is eliminated, a paint having conductivity is used as the coating material, and high

dc voltage is applied between the grounding and the insulatively shielded electrode.

[0021]

According to the construction, electrostatic coating can be carried out using a coating material having electrical conductivity and the spray gun can be compacted although the intensity and rate at which the atomized coating material particles can effectively be electrified are slightly reduced.

[0022]

Furthermore, the invention of claim 6 is the electrostatic coating spray gun according to any one of claims 1 to 5 which is characterized in that part or all of the electrical insulation material covering the surface of the insulatively shielded electrode is eliminated.

[0023]

In the case of the above-described construction, there is a possibility that electric current may flow between a part of the electrode 20 which is not insulatively coated and the pin electrode 20. However, since the electrodes are accommodated in the interior of the air cap, current needs to flow through air spouting port with a relatively smaller diameter, and a path along which current flows is increased such that the resistance value of the path is increased. Accordingly an amount of current flowing is small. Furthermore, although it is concerned that electrically charged coating material particle flows to the electrode, compressed air is spouted out of a pattern air flow channel vigorously and accordingly, there is a low possibility that the coating material particle can reach the electrode

against the flow of compressed air. Thus, electrostatic coating can be carried out and the spray gun can be compacted although it is difficult to apply such a high voltage as each aforesaid invention between the electrode and the pin electrode.

[0024]

Furthermore, the invention of claim 7 is the electrostatic coating spray gun according to any one of claims 1 to 6 which is characterized in that a shaping air spout port is provided at the outside portion of the outer cylinder of the air cap in the vicinity of the tip end of the barrel being the main body of the electrostatic coating spray gun, and compressed air is spouted forward along the outer cylinder surface of the air cap from the corresponding shaping air spout port.

[0025]

According to the construction, electrically charged coating material particle flowing toward the electrode along the electric line of force penetrating the air cap outward is blown away forward by shaping air, whereupon the coating material particle can be prevented from adhering to an outer surface of the air cap.

[0026]

[Description of embodiment]

Hereinafter, a description is given of Embodiment 1 of an electrostatic coating spray gun (hereinafter called a "spray gun") according to the invention with reference to FIGS. 1 to 4. A spray gun according to the embodiment mainly uses, as a coating material, aqueous coating material or metallic coating material whose electric resistance is relatively low. FIG. 2

depicts a longitudinal sectional view of the entire structure of a spray gun 1 according to the embodiment. FIG. 1 depicts a longitudinal sectional view of the tip end region. FIG. 3 depicts a front elevational view of a tip end air cap 40 described later.

[0027]

The spray gun 1 is composed of a barrel (gun tube) 2, which is the main body of a gun, and a grip 3 attached to the rear end region thereof. The barrel 2 is made of an insulative synthetic resin material and is formed to be columnar as the entirety. The spray gun 1 incorporates a high voltage generation circuit. A longitudinally long cascade 4 in which a step-up transformer necessary to generate high voltage and a high voltage rectification circuit are molded to be integrated together is accommodated in the upper part of the barrel 2. The high frequency voltage stepped up by the step-up transformer is multiplied and rectified by a Cockcroft-Walton voltage multiplying rectifier circuit to generate high dc voltage which is several tens of thousands volts. Generated high dc voltage is supplied through the high resistor into electrodes which will be described later.

[0028]

A coating material is supplied from a coating material tank (not illustrated) to a coating material hose joint 6 attached to the lower part of the grip 3 through a coating material hose (not illustrated). Then, the coating material is led into a valve chamber 9 of a coating material valve 8, passing through a coating material tube 7 therefrom. The coating material valve 8 is composed of a valve chamber 9, a needle 10 having a forward end

part tapered and penetrating the valve chamber 9 in its longitudinal direction, a guide hole 11 guiding the portion, which is rearward of the valve chamber 9 in the needle 10, movably in the longitudinal direction, a valve port 13 which causes the coating material nozzle 12 described later, which is fixed at the front end of the coating material valve 8, and the valve chamber 9 to communicate with each other, and at the same time, is opened and closed by the tapered front end portion of the needle 10 being brought into contact with the valve port 13 and being separated therefrom, and a packing 14 which is mounted between the valve chamber 9 and the guide hole 11 and is adhered to the outer periphery of the needle 10 in a liquid-tight state.

[0029]

The needle 10 in the coating material valve 8 is always kept in a closed state, where the valve port 13 is blocked, by pressing of a reset spring 15 secured at the rear end portion of the barrel 2, and prevents the supplied coating material from being discharged into the coating material nozzle 12. The needle 10 is caused to retreat against the reset spring 15 only while the trigger 16 is pulled, wherein the valve port 13 is opened, and the coating material valve 8 is entered into an open state. When the coating material valve 8 is opened, the coating material supplied into the valve chamber 9 is discharged into the coating material nozzle 12 attached forward of the coating material valve 8.

[0030]

A coating material nozzle 12 made of a synthetic resin material or a metal has an axial center through which a coating

material flow channel 29 extends in order that the coating material discharged out of the coating material valve 8 may flow therethrough. The distal end side of the coating material nozzle 12 is tapered. A coating material delivery port 19 having a small diameter and projecting is formed in the distal end. Furthermore, an atomization air flow channel 18 through which atomization air is caused to flow is formed in a radial outer peripheral side of the coating material flow channel 17 in the coating material nozzle 12, so as to be substantially parallel to the coating material flow channel 17.

[0031]

A metallic pin electrode 20 whose diameter is smaller than the inner diameter of the coating material delivery port 19 is projected forward and is inserted into the coating material delivery port 19. The rear end side of the pin electrode 20 is formed to be coil spring-shaped, and is accommodated in the coating material flow channel 17, the pin electrode 20 is retained in a forwardly projected state by pressing of the spring. In the embodiment, an aqueous coating material and metallic coating material whose electric resistance is relatively low may be used as a coating material. The metallic pin electrode 20 is electrically connected to a grounded coating material tank (not illustrated) by conductivity of the coating material and is maintained at the grounding potential.

[0032]

Compressed air for atomization air and pattern air is supplied to an air hose joint 21 attached to the lower part of the grip 3 from a compressed air generating apparatus (not

illustrated) through a high-pressure air hose. The compressed air passes through the air flow channel 22 in the grip 3 and is led to an air valve 23 provided at the rear end region of the barrel 2.

[0033]

The air valve 23 opens and shuts the compressed air supplied by a valve body 24 which moves forward and rearward along with the needle 10. When the coating material valve 8 is opened, the air valve 23 is also opened. When the coating material valve 8 is closed, and the air valve 23 is also closed. When the air valve 23 is opened, the compressed air is supplied to the annular atomization air flow channel 18 at the rear end of the coating material nozzle 12 and the annular pattern air flow channel 25 through the atomization air feeding channel 18 and the pattern air feeding channel, which are provided in the barrel 2.

[0034]

An air cap 26 made of an insulative synthetic resin material and covering the distal end side of the coating material nozzle 12 is fixed to the distal end of the barrel 2 by a retaining nut 27. The air cap 26 is formed to be double-cylindrical and has an inner cylinder 26g including coating material nozzle 12 side distal end which is formed into a tapered shape and fitted into a tapered recess formed in an outer peripheral distal end of the coating material nozzle 12. A flow channel of atomization air is provided between the inner cylinder 26g and the tapered distal end of the coating material nozzle 12. The flow channel of atomization air communicates with an annular atomization air flow channel 18. Furthermore, a pattern air flow channel is

provided between the inner cylinder 26g and an outer cylinder 26h of the air cap 26 and communicates with a pattern air flow channel 25 formed at the axial outer side of the coating material nozzle 12.

[0035]

A coating material nozzle insertion hole 24b is drilled in an axial center of a front wall 26a of the air cap 26. A nozzle distal end is inserted into the coating material nozzle insertion hole 24b. The nozzle distal end is provided on a distal end of the coating material nozzle 12 and forms a coating material spouting port 19 into which the pin electrode 20 is inserted. A narrow gap is defined outside the coating material spout port 19 in the coating material nozzle insertion hole 26b.

[0036]

Furthermore, a plurality of atomization air spout holes 26c are formed in the circumference of the coating material nozzle insertion hole 26b. Furthermore, square sections 26d and 26e opposed each other and projecting forward are formed at radial vertical positions with respect to the front wall 26a. The square sections 26d and 26e are formed with a plurality of pattern air spout holes 26f (two upper holes and two lower holes in FIG. 1) which are open toward an obliquely inside.

[0037]

When coating, compressed air passed through the atomization air flow channel 18 is spouted from the atomization air spout hole 26c and the coating material nozzle insertion holes 26b, and atomizes a coating material discharged from the coating material delivery port 19 of the coating material nozzle 12 by

the spraying principle. Simultaneously therewith, pattern air passed through the pattern air flow channel 25 and spouted from the pattern air spout hole 26f is blown onto the atomized coating material particles, the spraying pattern of the coating material particles is formed to be like an ellipse or oval suitable for coating.

[0038]

The greatest feature of the spray gun 1 according to the present embodiment resides in that insulatively shielded electrodes 28a and 28b whose surfaces are covered with an electrically insulating material 28c are accommodated in the interior of the above-described two square sections 26d and 26e which are provided at and projected from the upper and lower positions in the diametrical direction of the front side wall portion 26a of the air cap 26. Positive high dc voltage generated in the high voltage generation circuit is applied to the insulatively shielded electrodes 28a and 28b. The negative side of the high dc voltage is grounded via a return line (not illustrated) passing through the power source connector 5.

[0039]

The pin electrode 20 is in contact with a coating material having conductivity as described above, and is grounded at the coating material tank side via the coating material. Accordingly, high dc voltage of several tens of thousand of volts, which is generated in the high voltage generation circuit, is added between the insulatively shielded electrodes 28a, 28b and the pin electrode 28.

[0040]

Next, a description is given of operations and actions of the spray gun 1 according to the present embodiment thus constructed, with reference to a schematic diagram depicting connections of the electric system depicted in FIG. 4.

[0041]

When the commercial power supply is supplied to the high frequency voltage generation circuit 31 in the control circuit 30 provided near a coating material tank, high frequency voltage is generated at the secondary side of an output transformer 32 connected to the output side. The high frequency voltage thus generated is supplied via a power supply cable 33 to a step-up transformer 35 of a high voltage generation circuit 34 provided in the cascade 4 in the spray gun 1. The high frequency voltage stepped up by the step-up transformer 35 is rectified by a Cockcroft-Walton voltage multiplying rectifier circuit 36 to generate high dc voltage which is 30,000 through 60,000 volts. The generated high voltage is applied via a high resistor R between the insulatively shielded electrodes 28a, 28b and the pin electrode 20 via the high resistor R with the positive polarity set to the electrodes 28a and 28b. The electric lines of force emitted from the insulatively shielded electrodes 28a and 28b of positive polarity penetrate the air cap 26 formed of an insulating material, and the majority thereof reaches the grounded pin electrode 20. Since the pin electrode 20 is grounded via a coating material having conductivity, a large amount of negative charges is induced on the surface of the pin electrode 20 by electrostatic induction.

[0042]

In this state, when the trigger 16 is pulled, the coating material valve 8 is opened, and a coating material in the valve chamber 9 is supplied to the coating material flow channel 17 of the coating material nozzle 12 and is discharged from the coating material delivery port 19 at the tip end of the coating material nozzle 12. The discharged coating material flows forward, running on the pin electrode 20. A negative charge is induced on the surface of the pin electrode 20. Since the coating material has conductivity, the coating material is given a negative charge from the pin electrode 20 while it flows forward, running on the pin electrode 20, and is electrified with negative polarity (see FIG. 4).

[0043]

On the other hand, as soon as the trigger 16 is pulled, the air valve 23 is opened, and compressed air is supplied into the atomization air flow channel 18 and the pattern air flow channel 25 inside the air cap 26. The compressed air supplied into the atomization air flow channel 18 is spouted forward through the atomization air spout hole 26c, the coating material nozzle insertion hole 26b and the gap at the distal end of the coating material nozzle 12, is brought into collision with the coating material running on the surface of the pin electrode 20 and atomizes the same. The atomized coating material bursts out as particles in a state where it has a negative charge electrified while it is in contact with the surface of the pin electrode 20. That is, the bursting out coating material particles are electrified with negative polarity.

[0044]

The coating material particles thus atomized are burst out in the air with a charge induced when the coating material particles are brought into contact with the surface of the pin electrode 20. That is, the atomized coating material particles are electrified with an inverse polarity of the polarity of the electrode. On the other hand, the compressed air supplied into the pattern air flow channel 25 are diagonally actively spouted in front of the front wall 26a of the air cap 26 through the pattern air spout hole 26f . The pattern air forms the spraying pattern of atomized coating material particles to be like an ellipse or oval shape suitable for coating.

[0045]

However, the electric lines of force emitted from the insulatively shielded electrodes 28a and 28b are concentrated, in large quantities, at the tip end region of the pin electrode 20 as depicted in FIG. 4. Therefore, the electric field intensity in the vicinity of the tip end of the pin electrode 20 is remarkably increased, air is ionized, wherein electrons having negative charge and ions having positive charge are generated. The generated electrons are accelerated by an intensive electric field along the electric lines of force, resulting in an electron avalanche, and air is ionized to generate a large amount of electrons and positive ions. On the other hand, although the generated positive ions are directed to the negative pin electrode 20, are brought into collision with the electrode, and are neutralized, a large amount of electrons are discharged from the surface of the pin electrode 20 when being brought into collision.

[0046]

A large amount of electrons are generated in the vicinity of the tip end of the pin electrode 20 due to ionization of air and electron discharge from the pin electrode 20 based on such an electron avalanche, and are discharged to the periphery. As a result, a negatively ionized area in which a large amount of electrons exists is formed in the forward space area of the front side wall portion 26a of the air cap 26.

[0047]

Coating material particles atomized in a negative-electrified state are conveyed forward by the pattern air and pass through the negatively ionized area. When passing through, the coating material particles are given electrons and are further electrified with the negative polarity.

[0048]

The coating material particles passed through the negative-ionized area are further conveyed forward while forming an elliptical or oval spraying pattern by pattern air, and are conveyed to a close proximity of a substance to be coated. As the negative-electrified coating material particles approach the substance to be coated, positive charge is induced, by electrostatic induction, on the surface of the grounded substance to be coated. Thereby, the negative-electrified coating material particles are given an absorption force directed toward the substance to be coated, by an electrostatic force operating between the same and the induced positive charge.

[0049]

With both the absorption force based on the electrostatic

force and the blowing force based on the pattern air, the coating material particles are coated onto the surface of the substance to be coated. Since not only the blowing force based on the pattern air but also an absorption force based on the electrostatic force operate, the coating material particles are taken into the rear side of the substance to be coated, wherein a coating material is coated onto the rear side portion of the substance to be coated, which does not face the spray gun 1. Based on the above-described action, electrostatic coating is carried out on the substance to be coated.

[0050]

In the case of the present embodiment, there is a worry that negative-electrified coating material particles are directed to the insulatively shielded electrodes 28a and 28b along the electric lines of force, and the particles are adhered to the surface of the front side wall portion 26a of the air cap 26 and the surface of the square sections 26d and 26e thereof. However, since compressed air is actively spouted forward from the front side wall portion 26a of the air cap 26 through the pattern air spout hole 26f and atomization air spout holes 26c, adhesion of the coating material onto the front side wall portion 26a of the air cap 26 and the surface of the square sections 26d and 26e can be minimized.

[0051]

However, of the electric lines of force emitting from the insulatively shielded electrodes 28a and 28b, there are some electric lines of force which outwardly penetrate the outer cylinder 26h of the air cap 26. If such electric lines of force

exist, there is a fear that the coating material particles of negative charge, which are deviated from the spraying pattern, move along the electric lines of force and are adhered to the outward surface of the outer cylinder 26h of the air cap 26.

[0052]

In order to prevent such adhesion, the spray gun 1 according to the present embodiment is constructed so that a part of the compressed air is spouted forward from a shaping air spout port 27a secured at the retaining nut 27, which is concurrently used as a shaping air spout member. A number of shaping air spout holes 27a are disposed on the entire circumference of the retaining nut 27. Therefore, the coating material particles moved toward the surface of the outer cylinder 26h of the air cap 26 are blown off forward by the shaping air, wherein adhesion thereof onto the surface of the outer cylinder 26h can be prevented.

[0053]

In the case of the present embodiment, the surface of the insulatively shielded electrodes 28a and 28b is covered up with an electrically insulating material 28c. Accordingly, no current is flown between the insulatively shielded electrodes 28a, 28b and the pin electrode 20. That is, the current does not continuously flow from the high voltage generation circuit to the electrodes 28a and 28b, and high dc voltage generated in the high voltage generation circuit is used only for charging the electrostatic capacitance between the electrodes 28a, 28b and the pin electrode 20 and generating a high electric field therebetween. Therefore, it is sufficient that the load current supply capacity of the high voltage generation circuit is slight.

This is a point which is remarkably different from the external electrode system listed in the paragraph of the background art. No current flowing between the insulatively shielded electrodes 13a, 13b and the pin electrode 31 means that it is possible to make narrow the interval between the insulatively shielded electrodes 28a, 28b and the pin electrode 20. Accordingly, in the case of a spray gun 1 according to the present embodiment, there is an advantage in that a high electric field can be generated at the surrounding of the pin electrode 20 with a lower voltage than in the case of the external electrode system.

[0054]

In addition, the atomization of the coating material is mainly by atomization air as described above. However, it is considered that an outward electrostatic force operating on the coating material electrified with negative charge, which is in contact with the pin electrode 20, by an intensive electric field existing between the insulatively shielded electrodes 28a, 28b and the pin electrode 20 also contributes to the atomization.

[0055]

Since the negative-electrified coating material particles are adhered to a substance to be coated, by coming and flying from the pin electrode 20, a current is caused to flow from the substance toward the pin electrode 20, and the current flown into the pin electrode 20 is transmitted to the ground and is returned to the substance. That is, an electromotive force is produced along such a channel. That is, power generation is carried out. Energy necessary to produce the electromotive force is not supplied from the high voltage generation circuit 55 but from

compressed air. Such a power generation principle is similar to the power generation principle of Wimshurst Influence Machine.

[0056]

As described above, with the spray gun 1 according to the present embodiment, electrostatic coating using an aqueous coating material or a metallic coating material whose electric resistance is relatively low can be conducted in states where its coating material tank is grounded and adhesion of the coating material particles around the tip end of the spray gun 1 is reduced to the minimum. In addition, if the pin electrode 20 is grounded by a wiring cable, the spray gun 1 may be applicable to electrostatic coating using a solvent-based coating material whose electric resistance is high.

[0057]

The present invention is not limited to only the embodiment described above. The invention may be applicable to the following modifications and expansions. In the case of the present embodiment, although the insulatively shielded electrodes 28a and 28b are accommodated in the interior of the square sections 26d and 26e of the air cap 26, the insulatively shielded electrodes 28a and 28b may be attached so as to project forward from the square sections 26d and 26e in a state where the surface of the electrodes 28a and 28b is electrically isolated. Even in this case, it is a matter of course that electrostatic coating may be executed as in the above-described embodiment.

[0058]

Also, in the case of Embodiment 4, the insulatively shielded electrodes 28a and 28b are attached at the upper and lower

positions in the diametrical direction with the pin electrode 20 placed therebetween. However, they may be attached at the left and right positions in the diametrical direction. Thereby, although the spraying pattern of the coating material particles becomes slightly different from the case of the above-described embodiment, similar electrostatic coating may be carried out.

[0059]

In addition, in the case of Embodiment 4, the insulatively shielded electrodes 28a and 28b are provided by two in total. However, four square sections 26f and 26g projecting forward may be provided at the left and right positions in the diametrical direction with the pin electrode 20 placed therebetween (see FIG. 5). Also, a projecting ring-shaped portion 29 that surrounds the pin electrode 20 is formed instead of the above-described square sections 26d and 26e, wherein a ring-shaped insulatively shielded electrode 13d may be attached in the ring-shaped portion 29a (see FIG. 16). Thereby, the electric field intensity in the vicinity of the pin electrode 20 is intensified, and such an effect is brought about, by which the negative ionized area can be widened.

[0060]

Further, in the case of the present embodiment, positive high voltage is applied to the insulatively shielded electrodes 28a and 28b and the pin electrode 20 is grounded to the negative side. However, the polarity may be inverted. In the inverted case, the coating material is atomized with positive charge, and a positively ionized area is formed at the surrounding of the pin electrode 20. Then, the coating material particles may be coated

onto a substance to be coated, in a positive-electrified state, and electrostatic coating may be carried out as in the above-described embodiment.

[0061]

Also, in the case of the present embodiment, the pin electrode 20 is projected forward of the air cap 26 from the coating material delivery port 19 of the coating material nozzle 12. However, the embodiment allows for elimination of the pin electrode 20. In such a case, formation of the ionized area forward of the air cap 26 is slightly weakened in comparison with the case of the above-described embodiment. However, the coating material discharged from the coating material delivery port 19 is electrified with the negative polarity and is atomized. And, since the coating material particles are conveyed to a substance to be coated, by pattern air, with such an embodiment, electrostatic coating may be carried out.

[0063]

In addition, in this case, at least the tip end portion at the tip end of the coating material nozzle 12 at which the coating material delivery port 19 is formed may be composed of a conductive material such as metal. In such a case, such an effect can be brought about, by which electrification of the coating material particles can be further fostered than in a case where the tip end portion is composed of an insulating material.

[0064]

Further, in the case of the present embodiment, although the surfaces of the insulatively shielded electrodes 28a and 28b are covered and insulated by the electrical insulating material,

a part or whole of the surface of each electrode may be bare without being insulated by the electrical insulating material. In this case, there is a possibility that electric current may flow between the electrodes 28a and 28b and the pin electrode 20. However, since the electrodes 28a and 28b are housed in the air cap 26, the electric current needs to flow through the pattern air spout port 26f having a small diameter. Further, an amount of current flowing is small since a path of the electric current is rendered longer and the resistance value of the path is increased. Furthermore, it is concerned that the charged coating material particle should flow to the electrodes 28a and 28b. However, compressed air is vigorously spouted from the pattern air spout port 26f, there is a low possibility that the coating material particle would reach the electrodes 28a and 28b against the flow of compressed air. Accordingly, the electrostatic coating can be carried out although it is difficult to apply high voltage between the electrodes 28a and 28b and the pin electrode 20, and the spray gun 1 can be rendered compact.

[Brief Description of the Drawings]

FIG. 1 is a longitudinal sectional view depicting the tip end region of a spray gun according to the present invention;

FIG. 2 is a longitudinal sectional view depicting the spray gun according to the invention;

FIG. 3 is a front elevational view depicting a tip end of the spray gun according to invention;

FIG. 4 is a view of a frame format showing an electrical system of the spray gun and the operation thereof;

FIG. 5 is a front view of the tip end, showing a modified

form of the spray gun according to the invention; and

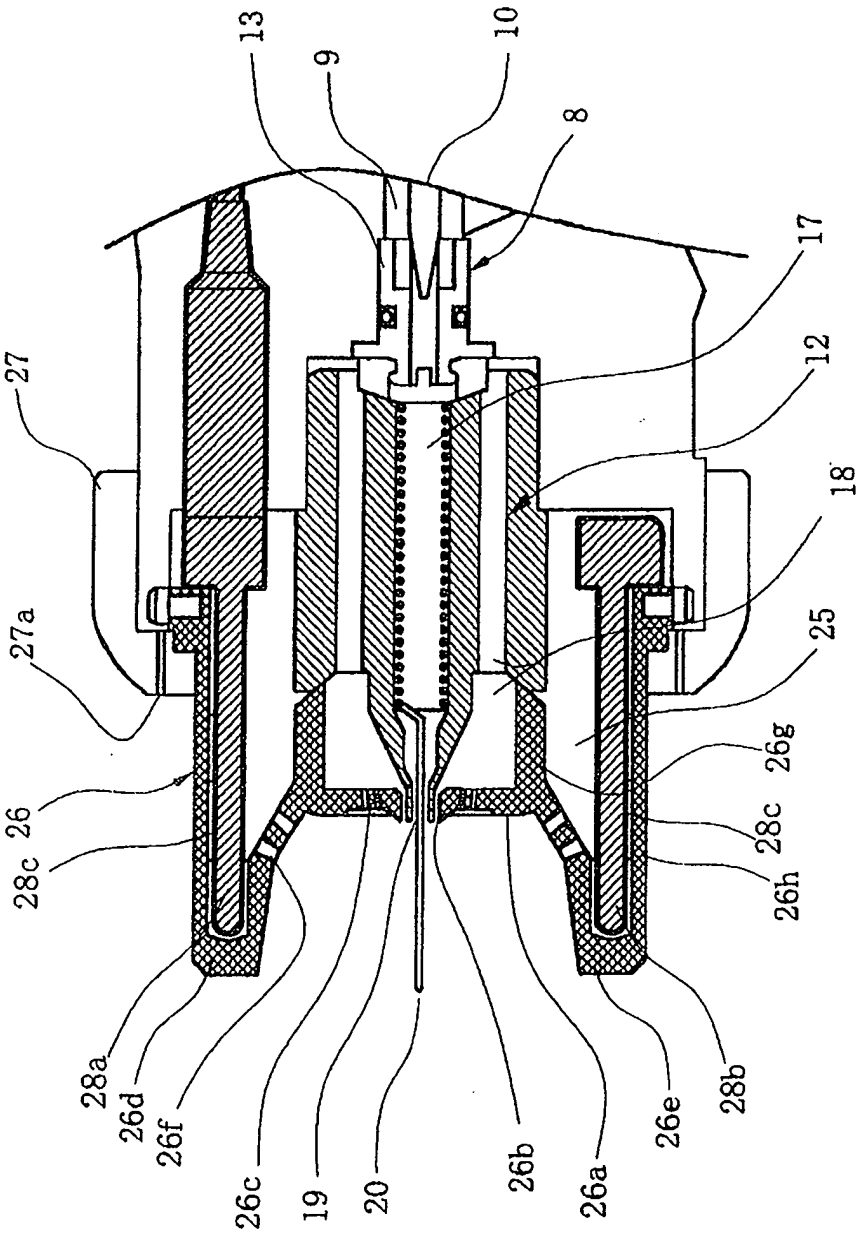
FIG. 6 is a front view of the tip end, showing another modified form of the spray gun according to the invention;

[Explanation of Reference Symbols]

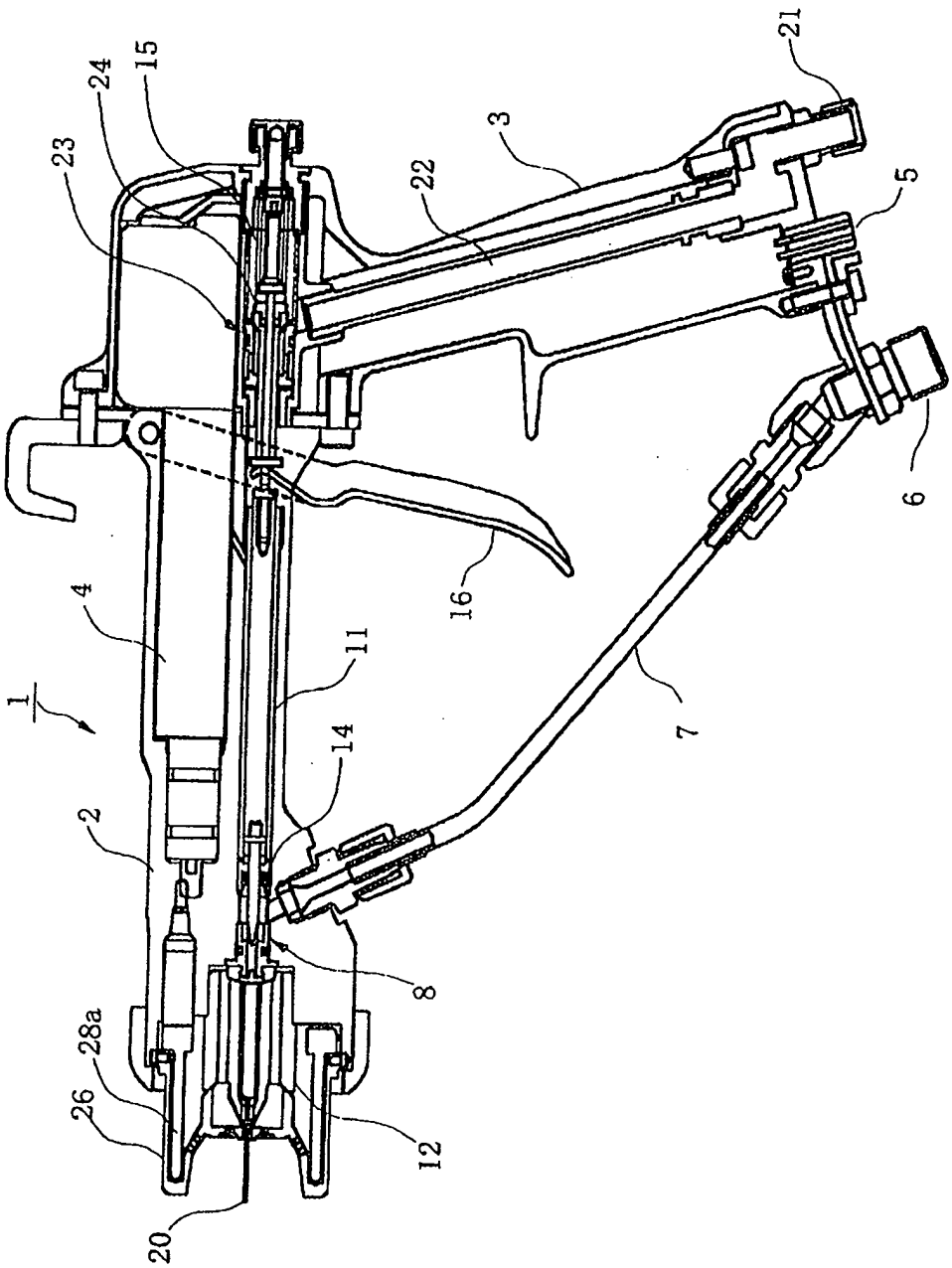
In the drawings, reference symbol 1 designates a electrostatic coating spray gun, 2 a barrel, 3 a grip, 4 a cascade, 8 a coating material valve, 10 a needle, 12 a coating material nozzle, 16 a trigger, 19 a coating material spout port, 20 a pin electrode, 23 an air valve, 26 an air cap, 26a a front wall, 26c a atomization air spout hole, 26d and 26e square sections, 26f a pattern air spout hole, 27 a retaining nut (shaping air spout member), 27a a shaping air spout port, 28a and 28b insulating coated electrodes, 28c an electrical insulating material, 29 a ring-shaped insulating coated electrode, and 29a a protruding ring-shaped portion.

[Name of Document] DRAWINGS

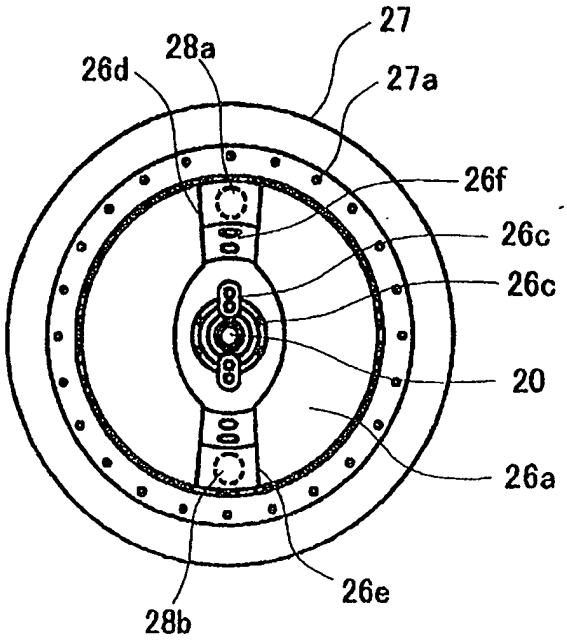
[FIG. 1]



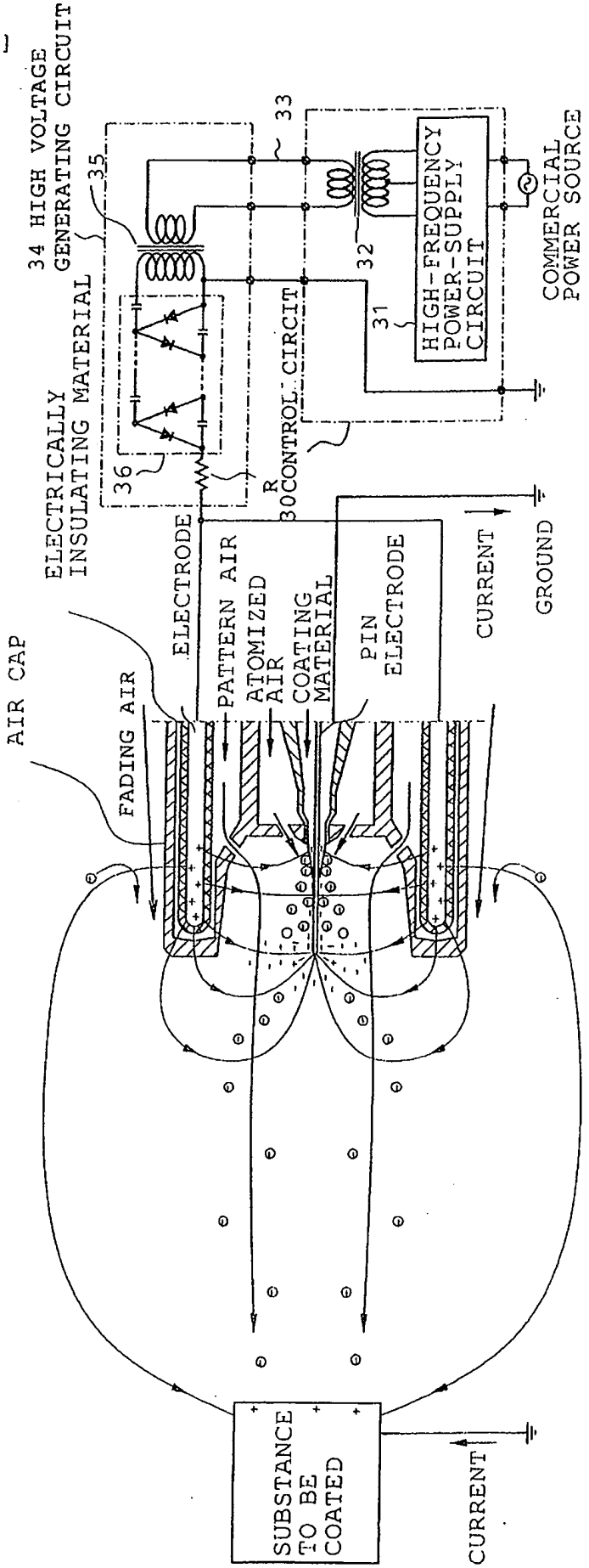
[FIG. 2]



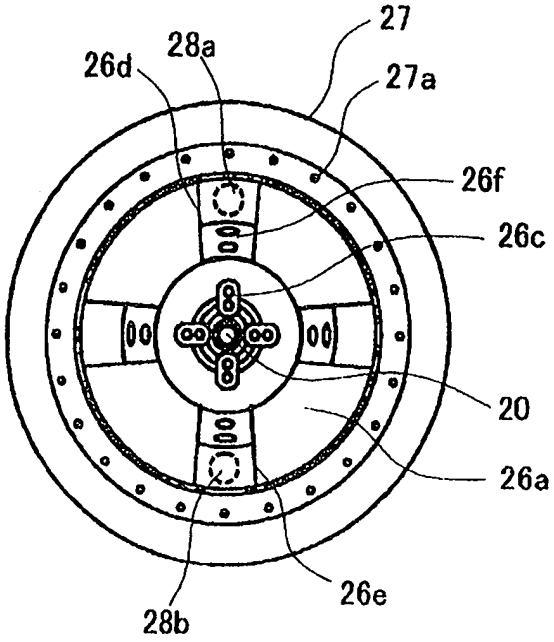
[FIG. 3]



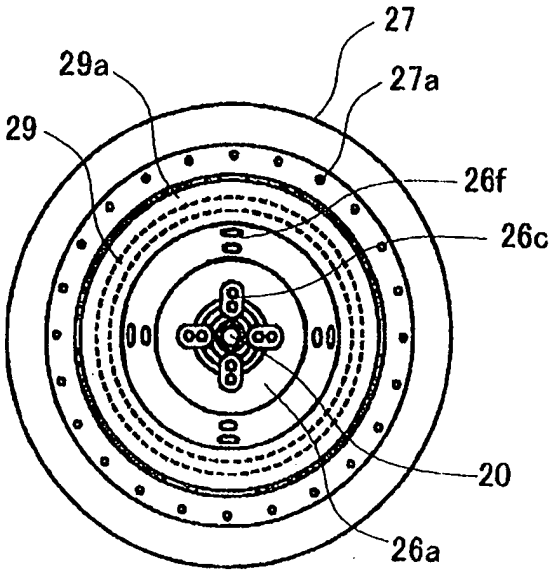
[FIG. 4]


34 HIGH VOLTAGE GENERATING CIRCUIT
35
33
32
31
HIGH-FREQUENCY POWER-SUPPLY CIRCUIT
COMMERCIAL POWER SOURCE
ELECTRICALLY INSULATING MATERIAL
36
R
30CONTROL CIRCIT
ELECTRODE
PATTERN AIR
ATOMIZED AIR
COATING MATERIAL
PIN ELECTRODE
CURRENT
GROUND
AIR CAP
FADING AIR
SUBSTANCE TO BE COATED
CURRENT

[FIG. 5]



[FIG. 6]



[Name of Document] ABSTRACT

[Abstract]

[Problem] Providing a compact electrostatic coating spray gun which can be used for electrostatic coating of aqueous coating material having a relative lower electrical resistance and metallic coating material.

[Overcoming Means] A pin electrode is provided which protrudes forward from a coating material spout port located in a central part of air cap mounted on a tip end of a barrel which is a body of a spray gun. Square portions are provided which protrude at radial upper and lower positions with respect to the air cap with the pin electrode being interposed between the square portions. Insulating coated electrodes having surfaces coated by an electrical coating electrode are housed in the square portions. The pin electrode is grounded and a high dc voltage is applied between the pin electrode and the insulating coated electrodes.

[Selected Figure] FIG. 1